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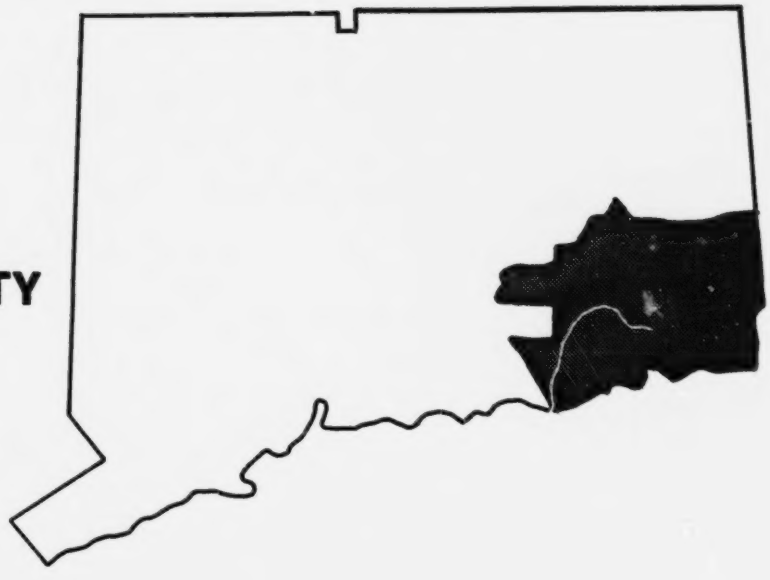
FLOOD INSURANCE STUDY

WAVE HEIGHT ANALYSIS

GROTON LONG POINT ASSOCIATION, CONNECTICUT

NEW LONDON COUNTY



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ANALYSIS OF WAVE HEIGHTS
FOR
GROTON LONG POINT ASSOCIATION,
NEW LONDON COUNTY, CONNECTICUT

Prepared by

for

FEDERAL EMERGENCY MANAGEMENT AGENCY

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1.0 INTRODUCTION

1.1 Background and Purpose

The Federal Emergency Management Agency (FEMA) recently adopted recommendations by the National Academy of Sciences to include prediction of wave heights in Flood Insurance Studies for coastal communities subject to storm surge flooding, and to report the estimated wave crest elevations as the base flood elevations on Flood Insurance Rate Maps (FIRMs).

Previously, FIRMs were produced showing only the stillwater storm surge elevations due to the lack of a suitable and generally applicable methodology for estimating the wave crest elevations associated with storm surges. These stillwater elevations were subsequently stipulated in community flood plain management ordinances as the minimum elevation of the lowest floor including basement of new construction. Communities and individuals had to consider the additional hazards of velocity waters and wave action on an ad hoc basis. Because there has been a pronounced tendency for buildings to be constructed only to meet minimum standards, without consideration of the additional hazard due to wave height, increasing numbers of people could unknowingly be accepting a high degree of flood-related personal and property risk in coastal areas subject to wave action. Therefore, the FEMA has pursued the development of a suitable methodology for estimating the wave crest elevations associated with storm surges. The recent development of such a methodology by the National Academy of Sciences has led to the adoption of wave crest elevations for use as the base flood elevations in coastal communities (Reference 1).

The low-lying shoreline areas of Groton Long Point Association are subject to periodic flooding by severe high tide levels and surf damage by wind-driven waves during hurricanes, tropical depressions, northeasters, and occasionally heavy summer thunderstorms.

Historic flooding in eastern Connecticut extends back to the early 17th century. Records indicate that the hurricanes of 1635 and 1638 caused extensive tidal flooding in coastal areas of Massachusetts and Rhode Island, probably the greatest ever experienced in New England during the past 340 years. Though no records exist for Connecticut, it is reasonable to assume that these hurricanes caused extensive tidal flooding of the Connecticut coast.

Records do indicate that the coast of Connecticut has experienced or has been threatened by hurricane tidal flooding on 66 occasions since 1769. On nine of these occasions severe tidal flooding did occur. The five greatest, as far as can be determined from existing records, were the

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hurricanes of 1938, 1893, 1954, 1815, and 1944 (in descending order of estimated magnitude). Losses due to the very severe hurricanes of 1938 and 1954 were approximately $6,000,000 and $3,000,000, respectively (Reference 2).

The low elevation of almost all of Groton Long Point makes it very susceptible to tidal flooding. Residences are heavily concentrated along the coastline and they are subject to damage from tidal flooding with wave action. Many residential and commercial structures are located in low-lying areas further inland and, though not subject to damage from the surf, they are subject to tidal flooding.

The southern portion of the point, in the Shore Avenue area, is exposed to the wave action from Fishers Island Sound and it is here that the most damage has occurred in the past. The shoreline structures along Mumford and Palmer Coves have also experienced wave action damage, but to a lesser degree.

The purpose of this study is to revise the FIRM for Groton Long Point Association, New London County, Connecticut, to include the effects of wave action for the following flooding source: Fishers Island Sound.

2.0 INVESTIGATIONS

2.1 Previous Studies

Storm stillwater elevations used in this analysis were developed by Dewberry and Davis (Reference 3). These elevations were developed by adjusting the elevations of the U. S. Army of Engineers (COE) publication Tidal Profiles for the New England Coastline using analysis of the New London, Connecticut tidal gage performed for the Flood Insurance Study for New London, Connecticut and using the profiles for the 1938 and 1954 storm events (References 4 and 5). These supersede the elevations used in the previous Flood Insurance Study for Groton Long Point Association (Reference 6).

2.2 Data Collection and Review

All available source data applicable for the wave height analysis were collected and reviewed. Because wave height calculations are based on such parameters as the size and density of vegetation, natural barriers (sand dunes), buildings, and other manmade structures, it was necessary to obtain detailed information on the physical and cultural features of the study area.

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Several sources were contacted for data. Aero Graphics Corporation of Bohemia, New York, was contacted for aerial photographs. The COE was contacted for stillwater elevations. The Connecticut Department of Transportation, Connecticut Department of Public Works, City of Groton, Town of Groton, and Groton Long Point Association were contacted for mapping. However, the work maps from the original Flood Insurance Study of Groton Long Point Association were found to be more accurate and so they were used. Groton Long Point Association was contacted for seawall elevations.

The principal source materials used for the wave height analysis are described below.

1. Aerial photographs (stereoscopic coverage) of Groton Long Point were obtained from Aero Graphics Corporation of Bohemia, New York (Reference 7). These photographs were taken in April 1980 and are at a scale of 1:12,000. They were used to determine the type, size, and density of vegetation and physical features.

2. Detailed topographic maps for Groton Long Point Association, Connecticut, at a scale of 1:1,200 were obtained from James P. Purcell Associates. These maps were made by Chandler and Palmer and were published in 1963 (Reference 8). These maps have a contour interval of 2 feet and contain many spot elevations. They were used as the work maps for the wave height calculations and for plotting wave elevations and the boundaries of the flood hazard zones (Section 3.1).

3. Stillwater elevations for the storm surges were obtained from the publication, Tidal Flood Profiles for the Connecticut Shoreline of Long Island Sound (Reference 3).

4. U. S. Geological Survey quadrangles of New London, Connecticut, and Mystic, Connecticut, were used for the placement of transects and for fetch computations (Reference 9).

2.3 Wave Height Analysis

The methodology for analyzing the effects of wave heights associaced with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 1). This method is based on three major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures described in Reference 1.

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The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch, length and depth.

Wave heights were computed along transects (cross section lines) that were located along the coastal areas, as illustrated in Figure 1, in accordance with the Users Manual for Wave Height Analysis (Reference 10). The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

Each transect was taken perpendicular to the shoreline and extended inland to a point where wave action ceased. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect. Table 1 provides a listing of the transect location and stillwater starting elevations, as well as initial wave crest elevations. All dunes and structures were assumed to remain intact for purposes of this analysis.

Areas exist within Groton Long Point Association where greater flood hazards may be expected than are presently indicated on the revised FIRM due to potential wave action. These areas include, but may not be limited to, Mumford Cove. Due to limitations of the data and engineering methodology, including a knowledge of wave generation and propagation mechanisms and wind-surge correlations in time, the magnitude and extent of wave hazard cannot be accurately determined at present and these areas have been omitted from rigorous analysis. As further refinements to existing study methods become available, the FIRM will be revised accordingly.

Figure 2 is a profile for a typical transect illustrating the effects of energy dissipation and regeneration on a wave as it moves inland. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations, and being increased by open, unobstructed wind fetches. Actual wave conditions in Groton Long Point Association may not include all the situations illustrated in Figure 2.

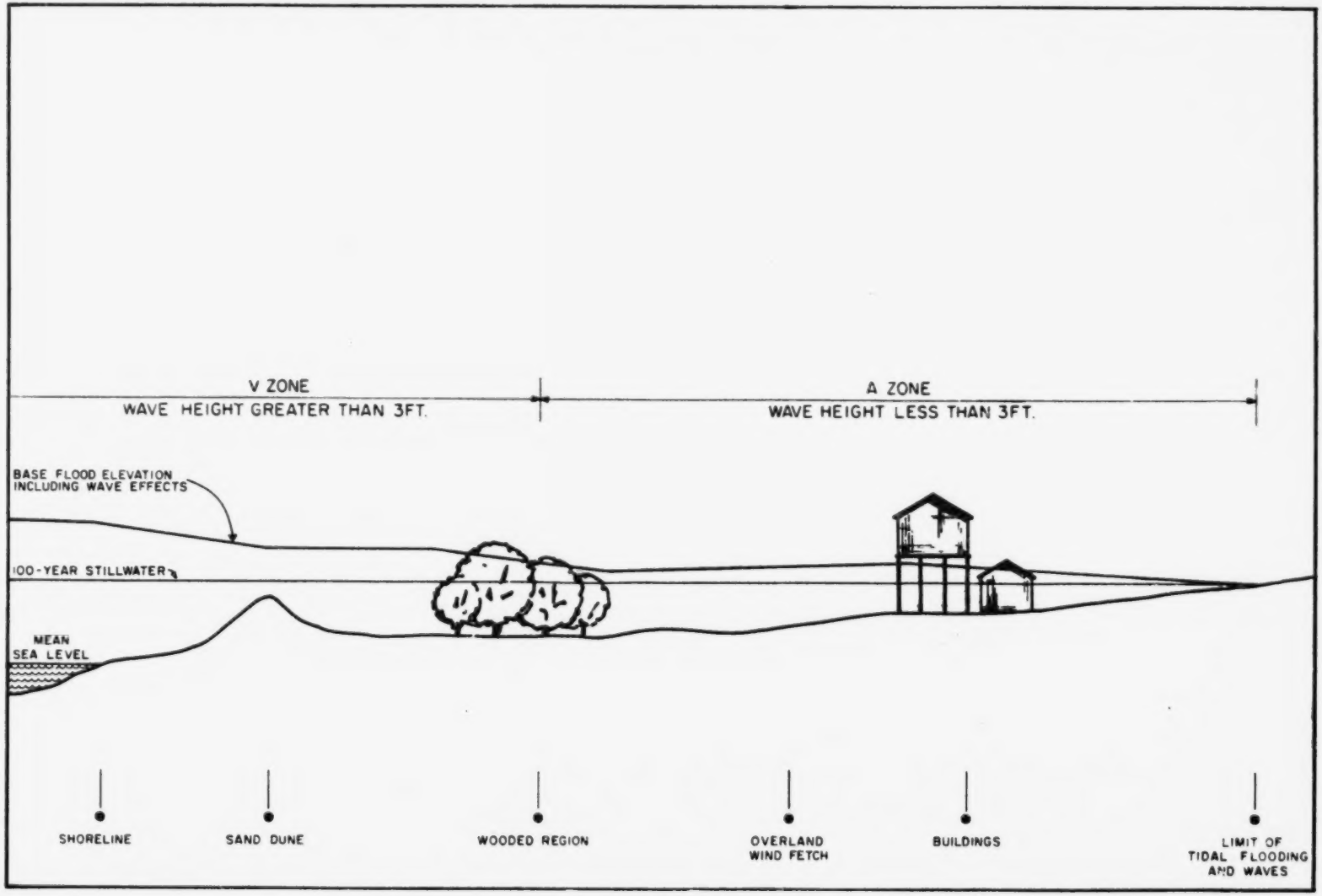

FIGURE 2
TYPICAL TRANSECT SCHEMATIC

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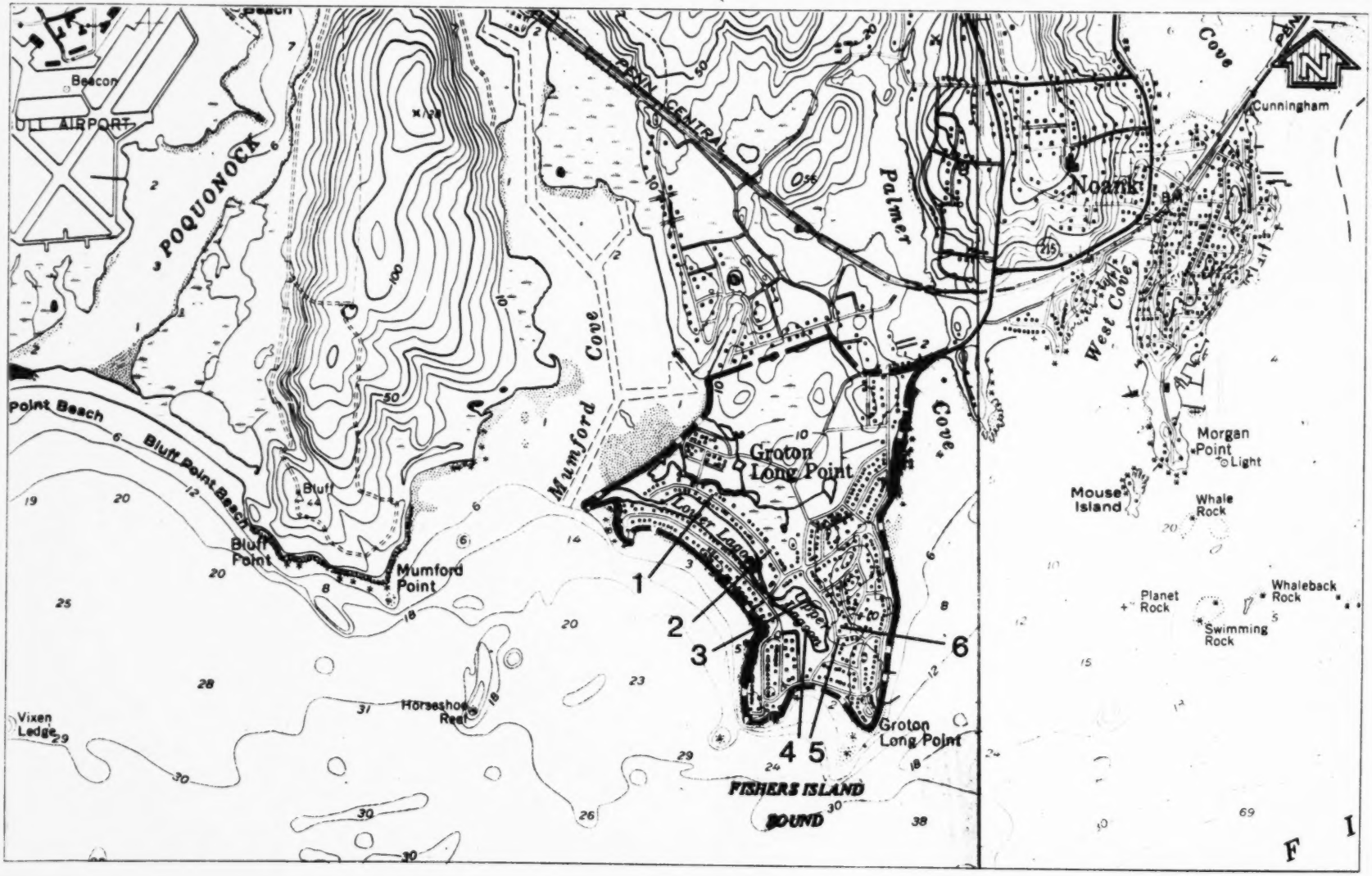

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

GROTON LONG POINT ASSOCIATION, CT
(NEW LONDON CO.)

APPROXIMATE SCALE

2000 0 2000 4000 6000 FEET

TRANSECT LOCATION MAP

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TABLE 1 - TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet) Stillwater 100-year	Elevation (feet) Maximum Wave Crest 100-year
No. 1	Atlantic Avenue, extended, to Venetian Street, extended	10.2	16
No. 2	Venetian Street, extended, to Beach Road, extended	10.2	16
No. 3	Beach Road, extended, to Weston Road, extended	10.2	16
No. 4	Weston Road, extended, to Sound Breeze Avenue, extended	10.2	15
No. 5	Sound Breeze Avenue, extended, to Groton Long Point	10.2	15
No. 6	Palmer Cove shoreline	10.2	15

After analyzing wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including the aerial photographs and the topographic work maps. Controlling features affecting the elevations were identified and considered in relation to their positions at a particular transect and their variation between transects.

2.4 Results

Computed wave heights and elevations associated with the 100-year storm surge are summarized below for various reaches in the study area.

Fishers Island Sound (Transects 1-6)

The flooding source for all flooding in the community is Fishers Island Sound which affects Mumford Cove to the northwest of the community and Palmer Cove to the east.

Waves greater than 3 feet affect the low-lying shoreline of the southwest, south and east areas of the community. In the southwest, waves greater than 3 feet progagate past the seawall and through the first row of buildings where the waves are reduced to less than 3 feet by

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the development. In the south, waves greater than 3 feet propagate past Shore Avenue South and up to the first row of buildings where the waves are again reduced by the development. In the east, waves greater than 3 feet propagate up to Shore Avenue East where they are reduced to less than 3 feet by rising ground elevations. Waves less the 3 feet propagate over Lower and Upper Lagoons and over the low marsh areas in the north and central areas of the community. Most of the community is subject to wave attack with the exceptions of some areas of high ground. These areas of high ground include a small area east of Weston Road, and areas around Club House Circle, Ridge Road and Prospect Street, and Burrows Street.

On September 30, 1981, the results of the study were reviewed at a final Consultation and Coordination Officer's (CCO) meeting attended by representatives of the FEMA, Groton Long Point Association, and Dewberry & Davis.

3.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage local governments to adopt sound flood plain management programs designed to reduce future flood losses. The FIRM for Groton Long Point Association has been revised to incorporate the latest available information, including wave height data, to assist these communities in developing the most appropriate and effective flood plain management measures.

3.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FEMA as the base flood for purposes of flood plain management. This flood has a 1 percent chance of being equalled or exceeded each year and is expected to be exceeded once on the average during any 100-year period. The risk of having a flood of this magnitude or greater increases when periods longer than 1 year are considered. For example, over a 30-year period, there is a 26 percent chance of experiencing a flood equal to or greater than the 100-year flood. The 500-year flood plain is also shown on the FIRM to indicate areas of moderate flood hazards.

Areas inundated by the 100-year flood are shown as A and V Zones on the community's FIRM. It is in these areas that the FEMA requires local communities to exercise flood plain management measures as a condition for participation in the National Flood Insurance Program.

3.2 Base Flood Elevations

Areas within the communities studied by detailed engineering methods have base flood elevations established in A and V Zones. These are the

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elevations of the base (100-year) flood relative to the National Geodetic Vertical Datum (mean sea level) of 1929. In coastal areas affected by wave action, base flood elevations are generally maximum at the normal open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the FIRMs. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. Base flood elevations shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the base flood elevation in A and V Zones.

3.3 Velocity Zones

The U. S. Army Corps of Engineers has established the 3-foot breaking wave as the criterion for identifying coastal high hazard zones (Reference 11). This was based on a study of wave action effects on structures. This criterion has been adopted by the FEMA for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program regulations require much more stringent flood plain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations.

The location of the V Zone is determined by the 3-foot breaking wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 100-year flood depth is insufficient to support a 3-foot breaking wave.

4.0 INSURANCE APPLICATIONS

The assignment of proper actuarial insurance rates requires that frequency and depth of flooding be estimated as accurately as possible. Because waves can add considerably to expected flood depths, it is important that insurance rates consider this additional hazard. The FEMA has developed a process to transform the data from this study into flood insurance criteria. This process includes the determination of Flood Hazard Factors and the designation of flood insurance zones.

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4.1 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables.

The FHF is shown as a three-digit code that expresses the difference between the 10- and 100-year flood elevations to the nearest 0.5 foot. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, the FHF is computed to the nearest foot.

4.2 Flood Insurance Zones

After wave elevations for the 100-year storm surge were determined and mapped, the study areas were divided into zones, each having a specific flood potential and FHF. Each zone was assigned one of the following flood insurance zone designations:

Zone V9: Special Flood Hazard Areas along coasts inundated by the 100-year flood as determined by detailed methods, and that have additional hazards due to velocity (wave action); base flood elevations shown, and zones subdivided according to FHFs.

Zone A7: Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones divided according to FHF.

Zone B: Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 2, "Flood Insurance Zone Data", summarizes the FHFs, flood insurance zones, and base flood elevations for the flooding source in the study area.

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TABLE 2 - FLOOD INSURANCE ZONE DATA

Flooding Source	Stillwater Elevation 10-Year	50-Year	100-Year	500-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Fishers Island Sound							
Transects 1-3	7.2	9.2	10.2	12.4	045	V9	12-16
					035	A7	10-12
Transects 4-6	7.2	9.2	10.2	12.4	045	V9	12-15
					035	A7	10-12

*Due to map scale limitations, base flood elevations shown on the FIRM may represent average elevations for the zones depicted.

4.3 Flood Insurance Rate Map

After flood insurance zones were established for the study area, the FIRM for Groton Long Point Association was revised to incorporate the new zone information. This map contains the official delineation of flood insurance zones and base flood elevations.

5.0 OTHER STUDIES

No wave height analyses for the adjacent City of Groton and Town of Groton are being conducted at this time and therefore the Flood Insurance Rate Maps for the City and Town of Groton will not be in agreement with this study (References 12 and 13).

6.0 REFERENCES

1. National Academy of Sciences, Methodology for Calculating Wave Action Effects Associated With Storm Surges, Washington, D. C., 1977.

2. U. S. Army Corps of Engineers, New England Division, Hurricane Survey, Interim Report, Connecticut Coastal and Tidal Areas, Waltham, Massachusetts, May 1964.

3. Dewberry and Davis, prepared for the Federal Emergency Management Agency, Tidal Flood Profiles for the Connecticut Shoreline of Long Island Sound, Fairfax, Virginia, February 1982.

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4. U. S. Army Corps of Engineers, New England Division, Tidal Flood Profiles for the New England Coastline, Waltham, Massachusetts, Janaury 1980.

5. U. S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of New London, New Haven County, Connecticut, Washington, D. C., December 1976.

6. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Groton Long Point Association, New London County, Connecticut, Washington, D. C., September 1979.

7. Aero Graphics Corporation of Bohemia, New York, for Connecticut Department of Environmental Protection, Aerial Photographs, Groton Long Point Association, Scale 1:12,000, April 1980.

8. Chandler and Palmer, Civil Engineers, Topographic Map, Groton Long Point Association Area, Scale 1:1,200, Contour Interval 2 Feet, January 1963.

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